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STUDIES IN PITCH DISCRIMINATION.

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In earlier articles¹ I have presented an exhaustive analysis of the process of pitch memory and pitch discrimination as conditioned especially by the individual observer and by varying time-intervals. The eight observers who took part in those experiments varied distinctly in their musical attainments, as was shown by a preliminary report of their 'musical history' as well as by their subsequent work in the experiments themselves. At least three of the observers were musicians of some ability; two, on the other hand, were quite unmusical. At the same time it was a matter of regret that the individual variations were not more pronounced.

More recently the opportunity has offered itself to examine two individuals, one of whom has the 'gift' of absolute pitch, the other of whom is a typical case of marked 'unmusicalness.' The first two of the following studies are concerned with these two cases.

The third study is likewise an outgrowth of my former articles.² It is an attempt to investigate somewhat briefly, in the case of an observer of musical ability, the memory and pitch discrimination of chords and melodies as compared with isolated clangs.

I.

The observer in the first study, Miss M. C. Meyer, a Sophomore in Cornell University, comes of a musical family, though her parents are not musicians. Her mother, however, sings somewhat; an older brother plays well by ear; a younger brother is almost tone-deaf; she, herself, of course, is very musical.

¹This *Journal*, XII, July and October, 1901, 409, and XIII, April 1902, 219.

²See especially *loc. cit.*, XIII, 268, the concluding paragraph.

This rather striking unevenness in the capacity of the family, especially in that of the children, all of whom presumably lived in nearly the same musical environment, suggests that the absolute pitch capacity is a specific, constitutional tendency, a specific extension of the general musical *Anlage*, which, in this case, was inherited by *M* as a variation from some of the musical ancestors, while her younger tone-deaf brother inherited no musical nature at all, resembling rather his parents and other ancestors.

This question of the source of musical ability and non-ability does not seem to me to be conclusively settled. And even if, as just suggested, we attribute the ability at bottom to a specific, transmissible nervous tendency, we do not preclude the possibility of greatly modifying this tendency by post-natal training, whether favorably or unfavorably. M. Meyer¹ has shown, for instance, in regard to this particular phase of the subject, how a very fair absolute pitch memory may be acquired by dint of insistent practice. I believe, however, that this would be impossible without an originally musical 'disposition.' We shall return to the general question in the second study.

M sings soprano, but has never received vocal instruction. On the other hand she was taught to play the piano at the age of eight, took lessons for a period of six years and has played considerably ever since. She also plays the violin a little. It is unfortunately impossible to determine more exactly the nature of *M*'s early musical training where it would seem most likely that the foundations for the exercise of absolute pitch memory must have been unconsciously laid, for the capacity was already well developed when first discovered by *M* at the age of 12. Though Köhler's method was first employed, two other teachers followed, each with his own particular method.

An examination of *M*'s musical imagery shows no trace of colored hearing, save that lively music is bright, like a flood of light, while depressing music is dark. Music is emotional, full of feeling, such that it might possibly under some conditions suggest colors, but none are ever actually seen.

Centrally excited musical imagery of various sorts is extremely prevalent. "I live to tunes some days." The whistle of the wind, the rumble of a heavy wagon, the confused murmur of a room full of people and various sounds in nature are full of musical notes for *M* and are constantly suggesting melodies to her. Most of the imaged music, however, is reminis-

¹ *Psychological Review*, VI, Sept., 1899, p. 514.

cential, not constructively created, being, for the most part, confined to melodies recently heard. If the source is in piano selections which *M* has herself played, the imaged music remains in that form; all other music is commonly translated into terms of *M*'s own voice. In trying actively to image a piano selection which she has herself played, *M* sees the score vaguely and also, just at first, the keys of the piano; besides this the finger movements are vaguely felt and the music is distinctly heard. In trying actively to image a selection which she has just heard, but has not herself played, *M* hears the music very distinctly and almost always tries to think of the finger movements. In general, the association of finger movements (motor, with or without visual accompaniments) is quite strong, so that, for instance, in listening to an organ recital, *M* is apt, or at least is able, to think all the finger movements that are being executed by the organist. This capacity seems one of the essential features of her absolute pitch memory.

Absolute pitch memory. When about 12 years old, as I have said, *M* discovered quite accidentally, while playing the piano in some school exercises, that she could assign the name to notes that she did not see played. Soon this capacity extended itself to a recognition of the pitch of other musical instruments and of the singing voice, though the piano was, and still remains, easiest to recognize, the violin next, while other instruments, especially those of unaccustomed color, and voices are more difficult.¹

In all cases the recognition is immediate—*i. e.*, not based upon any process of comparison or computation—and rapid. In all cases the recognition is in terms of visual and motor (tactual) processes; when a note is sounded there is an immediate visual picture of from two to five piano keys coupled with imagery of a motor sort, either of eye movement or of arm and finger movement (always of the right hand) toward a particular one of the visualized keys. In other words the

¹ Unusual tone colors, in other words, demand a special practice; if a stranger sings, it is not always possible to judge the absolute pitch of the notes sung at first, but after listening awhile, the association can be made with some exactness. The same thing holds true of pianos of different timbre; *M* can pass judgment upon them better after having played them for a few minutes.

recognitory judgment is a process like that of looking at, or more often of striking, a note upon the piano, save that it is all in terms of centrally-excited, instead of peripherally-excited, sensations.¹ The name of the note (auditory-articular) comes later as an association with the processes just mentioned.

There is never any confusion of the octave of the note sounded.² The motor accompaniments determine this part of the judgment. High and low regions are more difficult to judge, not in respect to the octave involved, but in respect to the particular note within the octave. The two best octaves are the once and the twice accented,—*i. e.*, those in which melodies are most played.

EXPERIMENTAL.

The accuracy and other characteristics of *M*'s absolute pitch memory were tested by a series of experiments with the piano. Sensible discrimination was tested by the Stern tone-variator actuated by compressed air.³

Pitch memory. In the short *preliminary series*, testing various octaves, emphasis was laid upon the introspection of the process of recognition. Of the qualitative results, the directness of the judgment and the prominence of visual-motor elements have already been mentioned. In addition the following points were established. (1) The interval sense is not used at all, even when conditions seem to suggest its aid, *e. g.*, giving notes separated by an octave or a fifth, etc., in immediately successive tests. In fact, *M* is not at all accurate in her designation of intervals. (2) Relatively high or low notes are not visualized as distinctly as those in the middle region. This is due, *M* thinks, to the fact that, in actual playing, she glances less often toward the outer octaves. (3) The speed of judgment is correlated with its assurance and its accuracy, *i. e.*, a rapid judgment is usually correct and given with assurance;

¹ Thus when *e'* was struck, *M* saw at once the keys *c'*, *c'*-sharp, *d'*, *d'*-sharp and *e'*, while *e'* 'stood out' (motor determinants) as the particular one sounded.

² Within the limits of the piano key-board.

³ By means of a device designed to furnish an air blast of uniform intensity which I have previously figured and described in this *Journal*, XIV, Jan., 1903, p. 107.

slow hesitating judgments are usually incorrect and given without assurance.¹

Of minor interest are several curious beliefs of *M*'s (not substantiated by the tests), such as that white notes are easier to recognize than black, that black keys have a smoother sound than white, that *b*-flat and *f*-sharp are easier to judge than the other black notes, that *d*-sharp is the most difficult note of all, that certain notes, in whatever octave they are found, have characteristic 'feels' quite aside from their place in the tonal continuum; *e. g.*, *f* in the small, the once and especially in the twice accented octave, is quite unpleasantly grating. This is the only hint of any peculiar mechanism for individualizing and remembering particular pitches. It does not appear, however, that *M* uses these supplementary associations at all in the process of naming the note, though, as we shall see, she is positive that they assist her in other ways. They are, in my opinion, to be regarded as purely incidental associations, themselves dependent upon the tonal memory, though they illustrate in a way the highly individual character that pitches may possess in the mind of a person who has absolute pitch.

Quantitatively the preliminary tests resulted in 70% correct judgments. Aside from a single mistake of a fifth, the errors did not exceed a major second, and the majority were minor seconds. It will be clear from this and subsequent tests that *M* does not by any means belong to that class of individuals who possess extraordinary fineness of absolute pitch memory. As Abraham has lately shown,² it is not uncommon for individuals to be able to detect, from memory, variations in the pitch of the *a* of small fractions of a semitone,—in his own case of four vibrations plus or minus.

In the *second series* of 75 tests confined to the once and the twice accented octaves the same point is brought out, for but 48 (64%) were judged correctly, 17 were too high, 10 too low. Of the errors 21 amounted to a semitone, six to a tone. Of the

¹This intimate correlation between these three factors corresponds entirely with what I have invariably found true in examining the judgment process. Cf., *loc. cit.*, XII, 445-6.

²Das absolute Tonbewusstsein. Psychologisch-musikalische Studie. *Sammelhefte d. intern. Musikgesellschaft*. Berlin, 1901.

21 semitones, again, 19 were errors in which *M* designated an adjacent black instead of a white key. This is one of numerous bits of evidence to which we shall call attention, all of which show that *M* is an observer of a decidedly subjective type,—suggestible,—given to unconscious prejudice and bias. These erroneous judgments of black keys for white ones, for instance, ensued after she had tried the experimenter's piano, commented upon its 'mellowness' in comparison with her own, and stated that this smoothness made all the notes seem like flats. More particularly when, at the 12th test, some remarks were made about the recognition of the black keys, *M* assigned a black key in every one of the next 12 tests.

It must be borne in mind that all of the above experiments were made upon a comparatively unfamiliar piano whose notes seemed to *M* not only less brilliant but also less distinctive in character than those of her own.

Accordingly the *third series* of tests was made upon *M*'s piano. The results (for 100 judgments in the once and twice accented octaves) entirely confirmed *M*'s belief that she could give more accurate answers with this instrument. 92 judgments were correct. The eight errors were equally divided between too high and too low, and equally divided between major and minor seconds.

A *fourth series*, conducted by *M* upon her own piano, showed that fusions of two, three and four notes in the two octaves previously used could be correctly analyzed and named, note by note, in approximately 85% of the trials. The errors, as a rule, affected but one or two notes in the chords.

Abraham has shown by statistics that only 35% of those who boast absolute pitch memory are able to reverse the usual process, *i. e.*, to ideate or sing a note whose name is given. He adds that these are the individuals whose pitch memory is especially strong, rapid and capable of fine discriminations. We have seen that *M*'s memory is not extraordinarily fine; she is liable to err from a half to a whole tone in from 8 to 35% of the trials (depending largely upon her familiarity with the instrument employed). On the other hand she is able, at will, to ideate pitches with practically the same degree of accuracy. In a few cases the imaged note varied from the true pitch by a

half-tone, never more; in most cases there was no appreciable error. *M* believes that she is aided in this process, much more than in the tests of the first sort, by the fact, already mentioned, that each note has some peculiar characteristic. "The note *f* has a peculiar, harsh, grating quality which cannot be mistaken; *b* has a sad, melancholy sound; *c* a soothing, restful quality, *e* a lively, cheerful sound," etc.

Sensible Discrimination. Tests of qualitative sensible discrimination were made with the idea of seeing whether *M*'s absolute pitch memory would be of any aid in the detection of fine tonal differences. Incidentally this work developed several points of interest in regard to the use of various methods with an observer of the subjective type.

The method of minimal changes proved impracticable, notwithstanding every effort to insure a proper attitude on the part of the observer. Thus a typical series, proceeding from too high (4.9 vibs). to objective equality, contains the following series of judgments,—higher (4),² slightly higher (2), equal (2), lower (1), equal (2), lower (2). When the variable proceeded in the reverse direction, *i. e.*, from objective equality upward, the judgments were,—lower (2), slightly lower (2), higher (6), equal (1), higher (3).

Merkel's modification of right and wrong cases met with no better success. Despite all attempts to avoid bias *M* judged 'unequal' almost invariably even with a very small *D*, being aware that differences were always being given objectively.

It was necessary, accordingly, to introduce 'equal' cases, and Kämpfe's form of the method was employed. This was more satisfactory, though an inexplicable tendency to give the judgment 'higher' modified the results of some series. In 200 cases, with $D=0.7$ vib., *M* had 65.5% right, 24.5% wrong, 9.5% equal and 0.5% doubtful cases. As computed from Fechner's table, these figures give $S=0.18$ vib., a value slightly, but inappreciably, less than the average difference limen for practiced observers in this region. When we take into account the relatively small number of cases used, and the existence of an obscuring judgment tendency, it is safe to con-

²The figures in parenthesis indicate the number of times the judgment was given successively.

clude that *M's sensible discrimination is no finer than that of musical observers who have no absolute pitch memory*. The absence of any beneficial effect from the absolute pitch memory is attested further by the fact that no absolute memory of the stimuli employed was developed although the tests succeeded each other quite rapidly.

Summary. This study has analyzed the basis and conditions of absolute pitch memory in the case of a single observer. The following facts have been ascertained.

(1) This particular pitch memory appeared rather spontaneously in a fairly developed form at about the age of 12 years, and is probably the outcome of an inherited musical *Anlage* supplemented by early musical training.

(2) Judgments of pitch can be made of either instrumental or vocal music, though the latter is more difficult.

(3) In all cases the judgment is direct, very rapid and in terms of visual-motor imagery having reference to the piano key-board.

(4) Under optimal conditions piano notes can be correctly identified approximately 92 times in 100; the errors are then mostly semitones and never exceed a tone.

(5) Accuracy of recognition is diminished if the clang-color of the note is unfamiliar.

(6) The octave in which the given note lies is never mistaken.

(7) Recognition is most accurate in the once and the twice accented octaves.

(8) Contrary to the generalization of Abraham, this observer, though possessing but a fair accuracy of recognition, is able to image and reproduce assigned pitches with as much accuracy as she can name them when heard.

(9) Sensible discrimination is no finer than that of the average practiced musical observer and is not aided in any way by the absolute pitch memory.

(10) With an observer of the 'subjective' type, the gradation methods are not practicable: Kämpfe's modification of right and wrong cases seems most satisfactory.

II.

The second study was planned to investigate rather thoroughly the mental type of an unmusical observer, to examine the factors which prevented good discrimination, and finally, to see whether there could not be found in systematic drill and coaching properly directed some remedy for the defects revealed.

Miss M. B. Park, a Senior in Cornell University, was selected as observer for this study, because, while she represented the extreme type of unmusical observer, she nevertheless found marked pleasure in listening to music and was eager to improve her knowledge of it.

General 'Ideational Type.' An examination *P*'s mental imagery by the questionnaire method¹ showed that, of the minor senses, taste imagery was very poor, that of smell entirely lacking, while tactual, thermal, and organic sensations were rather better than the average. Emotional associations were, in consequence, quite vivid.

As regards the 'higher' senses, visual imagery was perhaps equal or somewhat better than the average, the visualization of the characters and scenes of a novel, for example, being so satisfactory and distinct as to cause a dislike of illustrations in the book itself. Auditory imagery, music excepted, is also at least equal to the average. Thus *P* can recognize her friends by their voices, can ideate easily the buzz of an induction coil, the crack of a whip, the hum of bees, the slam of a door, the clink of teaspoons in a saucer; but the sound of a church bell is imaged with some difficulty and the beat of rain against a window-pane can not be imaged at all.

In general *P* makes much less use of auditory than visual imagery. "A thing seen means much more to me than a thing heard." Musical imagery will be discussed below.

She easily distinguishes waltzes from two-steps, not directly as musical (auditory) rhythms, but from the way her feet naturally move in dancing to them.

P's ancestors were musical on the paternal side, unmusical on the maternal. None of her brothers or sisters is musical. During her childhood she heard little music, was taught none.

¹As given by Titchener; *Manual of Experimental Psychology*, I, 198 ff.

Her parents assumed that she was unmusical and never encouraged her to try to sing. On the contrary she was told, as a matter of fact, that she would never be able to sing. In consequence she became, in her girlhood, very timid about her lack of musical capacity. When placed in a school chorus at the age of fourteen she shrank from any attempt at singing, saying when urged, "I don't even know how to try." She was excused from the exercise because she received no benefit from it.

Of the rudiments of written music she has merely a hazy knowledge of the names of the notes and their places on the staff.

On the other hand there is to be noted an enjoyment in music, rather uncommon for the unmusical, especially the music of the violin, church organ and other instruments. Such music arouses vivid emotional reactions and often complex associations. "I make up a story about each piece I hear." There are also interesting synæsthetic associations of tactual and visual form with music. Thus the voices of singers are square, thin, round, etc.; violin notes are similarly round, square, triangular, flat, thread-like (drawn out), etc. Round notes are smooth and stand out alone; "triangular ones have corners which would hurt if they touched you." These simultaneous form associations seem to me interesting, as possibly indicating a general tendency, on the part of unmusical individuals, to transfer musical perceptions from auditory into other modalities.

Musical Imagery. The prevalence of centrally excited tunes seems to us the most curious thing in *P*'s ideational type. Tests with the piano, while actually listening to the notes, showed (1) that she could not distinguish any difference between a major and a minor triad, (2) that she could not detect changes of a half tone in a 'familiar' melody, (3) that she could not detect harmonic errors save those of a striking sort. Furthermore other tests showed that her memory for pitch and for melodic forms was extremely poor.

She could not, for example, recall, or even recognize when played, the simple sol, mi, sol, do, sol, mi, do, mi, of the library tower clock in announcing the hour, though this must have

been heard two or three thousand times during her life at the university. In fact, she never even knew that the quarter, half, three-quarter and hour bell-strokes were always uniform.

Yet in answering the questionnaire *P* reported that "there is scarcely any time when 'tunes' of some kind are not felt." She says further, "I can sing tunes 'on the inside,' but cannot imagine myself singing them 'outside.' I cannot mentally hear an organ play or people sing any assigned selection. I simply have what are tunes to me, but they may not be to other people. I don't recall music, but imagine it."

Since *P* does not sing it is difficult to check the correctness of these 'tunes.' But she whistles somewhat, and judged by this form of expression the imaged melodies are not at all accurate. Thus she said she could ideate a certain 'familiar' church hymn in a way that seemed to her entirely correct, but when she whistled it, it was difficult to recognize the tune save from the rhythm, which was correctly given.

We conclude, therefore, that the ideated tunes which form such a predominant feature of this unmusical observer's mental imagery, are, for the most part, purely imaginative and that, when they take the form of the reproduction of music previously heard, they are very inaccurate. It may be surmised, too, that the auditory element is subordinate to the rhythmical, *i. e.*, that the so-called 'tunes' are not so much tonal as 'motor.'

Experimental Tests. As an observer, *P* formed a decided contrast to *M*. She had the advantage of training in laboratory psychology and, in addition, fell naturally into the attitude of an 'objective' observer. Her answers were given carefully and with assurance. For sensible discrimination two instruments were employed,—the piano, to meet the usual musical conditions, and the Stern tone-variator, to secure finer gradations and equalized intensity.

A. With the variator. In the first crude tests *P* was frequently unable to judge correctly a D of 12 vibs. (with standard approximately 250 vibs.). But practice rapidly increased the discriminative sensitivity. In the regular series it was found more advantageous to employ Kämpfe's form of right and wrong cases than minimal changes. When a D of 2.8 vibs. was used, 200 tests gave 78% right, 9.5% wrong, 9%

equal and 3.5% doubtful cases. As computed from Fechner's fundamental table these figures indicate 0.52 vibrs. as the value of *S*, a value obviously not much greater than that of practiced and musically trained observers.

B. With the piano. Two series by the method of right and wrong cases were conducted with the piano, the first before, the second after, the tests with the variator. Three pairs of stimuli were chosen, the notes *c'* and *c'* sharp, *f'* sharp and *g'*, and *b'* and *c''*, *D* being, therefore, approximately 17, 24.5, and 33 vibrs. respectively.

In the first series 40, 74 and 70% of right cases were recorded for these three pairs of notes, indicating a somewhat supraliminal difference in the two higher pairs,¹ but a subliminal difference in the lower pair. It seems unwarrantable that this curious drop should be due merely to the slightly lower tonal region and the consequent diminution of *D*. And, in fact, an examination of the judgments reveals the existence of a strong tendency to pass the judgment 'lower' when the pitch of the stimuli was lower than the once accented octave. I shall discuss this more fully below.

In the second series with the piano there were 68, 68 and 78% of right cases for the three pairs of stimuli respectively. It will be observed that the practice with the variator, which intervened between the two piano series, did not appreciably improve the discrimination of half-tones upon the piano. The right cases for the lower pair have, to be sure, now exceeded 50%, but the same tendency to judge 'lower' is still prominent.

Secondary Factors. It is well known that the pitch discrimination of an unmusical observer, whose mind moves with difficulty in the sphere of tone perception, is easily influenced by secondary factors which do not affect the judgment of a practiced musical observer. It was one of the objects of this study to detect the most prominent of these influences. In the case of *P*, the variator and piano tests above mentioned, when supplemented by special piano tests, revealed clearly as many as six conditions or influences that made against successful discrimination.

¹It may be noted, however, that fewer right cases are recorded than for the variator where *D* was only 2.8 vibrs.

(1) First may be mentioned the peculiar individual tendency already cited,—that of judging ‘lower’ when the stimuli were of relatively low pitch. In the first piano series of 50 tests this judgment occurred 40 times, in the second 39 times, when the lower pair of stimuli was used.¹ The strength of this tendency may be seen by the results of subsidiary tests scattered over various octaves of the piano, in which it was shown that ‘lower’ was judged almost invariably when the stimuli fell below the once accented octave, and that this was true in some tests when the stimuli were separated, not by a half-tone, but by as much as a fifth, or less often, by more than an octave.

(2) There was a marked daily rise in efficiency, apparently a sort of ‘*Anregung*’ or ‘warming up.’ On this account the observations during the first 15 minutes of each experimental hour were rejected from the computations; otherwise the percentage of right cases would be very much lower. A typical series of 25 tests, the first in the hour, contains nine doubtful cases.²

(3) Although the tests were made in close succession and with a relatively large D, there were no traces of judgments in terms of absolute pitch, *i. e.*, no judgments given as soon as the first stimulus sounded. The reason for this was easily shown to lie in *P*’s inability to hold any image of the standard in memory for longer than four or five seconds, for when, accidentally in the variator tests, too long a time-interval (five or six seconds) elapsed between the stimuli, no judgment could be made. “I lost the first one before the second came.”

(4) On the other hand, too brief duration of the stimuli, or too short a time-interval, caused equal difficulty.³ This was brought out clearly by subsidiary piano tests in which it was found that judgments of higher or lower could not be made at all

¹The tendency was evidently here strong enough to vitiate the method. Had the remaining ten cases received the same judgment, the D in use would have, theoretically, stood exactly at the limen, *i. e.*, 50 instead of 46% of right cases.

²Almost invariably cases in which a difference was correctly judged, but its direction quite unknown.

³In the regular variator tests the interval was kept at approximately 1.50 seconds; in the piano tests, approximately one second.

when two notes separated by *more than two octaves* were struck briefly and in quick succession (*e. g.*, as 16th notes).

(5) Throughout all the tests the tendency to confuse intensive with qualitative changes was strikingly manifest. A slight or moderate accentuation caused the accented note to be judged 'higher;' a strong accentuation produced a general confusion such that no judgment at all was possible, even when the stimuli were *more than an octave apart*. Unquestionably this is a most important source of confusion to the unmusical. In our own tests it may account for the fact that *P* gave no more right cases for D's of from 17 to 33 vib. with the piano than for a D of 2.8 vib. with the tone variator whereby accidental variations of intensity were avoided.

(6) A pitch difference that could be discriminated with tolerable regularity, became imperceptible when the clangs were given in fusion with one or more other clangs. Thus the half-tone *e'' e''-flat* was, as a rule, correctly judged, but, when given simultaneously with *c''* and *g''*, not only was the direction of the change of the moving clang not discriminated, but no difference whatsoever was perceived between the two experiences, *i. e.*, there is for *P* no difference between a major and a minor chord. It might be predicted, possibly, that the qualitative relations of *e''* and *e''-flat* would suffer obscuration by fusion, but the degree of the obscuration seems unexpected until we remember *P*'s inability to hold a pitch in memory. Evidently this lack of accurate tonal imagery makes it impossible for *P* voluntarily to place her attention upon the constituent members of the chord, and to observe the qualitative changes.

We may summarize these tests of discrimination as follows. *We have found that a typical unmusical observer, when placed under proper conditions, may discriminate pitch differences of less than three vibrations correctly in 75% of the tests, but if the stimuli are of relatively low pitch, if they are given without any preliminary 'warming-up,' if the time-interval between them exceeds four or five seconds, if they are given too briefly or in too quick succession, if they are of unequal intensity, or if they are presented simultaneously with one or more other similar stimuli, then discrimination becomes either difficult or quite impossible,*

*and it may then remain impossible even when D is represented not by a few vibrations, but by musical intervals of one or two octaves and more.*¹

As already intimated, in the original plan of this study it was intended to throw light upon the relation between practice and constitutional tendencies. Musical inefficiency is often, like bad spelling, considered to be a fundamental, inherited defect, incurable by any amount of attentive effort. It may be readily admitted that it would be a hopeless task to attempt to transform into a skilled musician a person who is not only unmusical, but also utterly without interest or pleasure in music. But may not the case be otherwise when the unmusical individual finds pleasure in listening to music and is actively desirous of overcoming the deficiency of which he is conscious? May not insistent coaching and practice of the right sort supply to such an one at least the necessary structure, the basis upon which musical appreciation must rest?

Stumpf² has proposed as tests of musical capacity the ability (1) to sing a given note struck on the piano, (2) to judge which of two successive tones is the higher, (3) to judge whether one or two tones are present in fusions of high and low degree, and (4) to determine the relative pleasantness or unpleasantness of two chords separated by a short pause. If, then, any sort of educative influences could train an unmusical individual to meet these four tests successfully, the possibility of passing from the 'unmusical' to the 'musical' class would be open to any who would try. A new incentive, too, would be given the musical training of children, if we knew that environmental, rather than hereditary or innate, influences were responsible for the closing of one of the great avenues of æsthetic expression and enjoyment.

To the solution of this problem the present study has contributed little. Several experimental hours were given over to coaching, especially upon the pitch discrimination of piano notes of unequal intensity. The results were negative. As, moreover,

¹ Doubtless not all these conclusions would be applicable to every unmusical observer. We have summarized the results only for observer P under the conditions of our tests.

² *Tonpsychologie*, II, 157.

we have seen that the considerable practice in discrimination with the variator did not appreciably affect the discrimination of piano half-tones, it is evident that the study, as a whole, has rather strengthened the idea that an unmusical observer is constitutionally and inevitably unmusical, that there is an unmusical *Anlage* (if the term can be applied to a deficiency) quite as much as there is a musical *Anlage*, or a more specific *Anlage* to absolute pitch memory as in the case of *M*.

At the same time, the period given to the attempt to train observer *P* was extremely short. Possibly a much longer attempt would have accomplished something definite and permanent.¹ At any rate I believe that it is still an open question, and one worthy of solution, as to whether musical incapacity, especially when discovered in early childhood, may not be remedied by proper training. What is needed first, however, is a number of detailed studies of unmusical observers to supply data in regard to the type. I trust that the present contribution may interest others in the problem.

III.

MEMORY AND PITCH-DISCRIMINATION OF CHORDS AND MELODIES.

The idea of investigating the relative integrity in memory of the pitch of a chord or melody as compared with that of a clang, occurred to the writer in connection with some personal experiences which seemed to indicate that the pitch of a musical selection was correctly identified after intervals of time longer than those which, according to my experiments, limit successful recognition of isolated notes. It might be expected, too, that a chord or a melody, in virtue of complexity, would afford a less artificial material for experimentation, as the conditions would then more nearly resemble those of actual musical experience. It might be expected further, that, in accordance with the principle of individuation, a chord or melody, being more complex and specific than a single note, would, on

¹The rapid daily rise of efficiency shown in the tests lends some countenance to the general hypothesis that longer practice would bring noticeable improvement.

this account, be more easily retained in memory and more easily discriminated from other contents. Professor I. Madison Bentley, an experienced and musically gifted observer, kindly acted in that capacity in these tests.

A. THE CHORD.

Instrument and Method. At the outset the choice of an instrument presented difficulties, for the test required fine and rapid adjustment of at least three pitches.¹

In the absence of suitable instruments of precision we sought to take advantage, for some tentative tests, of the equal temperament afforded by the piano. The disadvantage of the piano, too large pitch differences, was overcome in three ways, —by the use of distraction; of a lengthened time-interval; and of pitches chosen as low as possible in order to minimize the difference in absolute vibration rate.

After several trials the following conditions were found most suitable. The triads *B-d-sharp-f-sharp*, and *c-e-g* (approximately 122, 156, 183.5, and 130.5, 163, 196 vibs. respectively) were used as stimuli. The method of right and wrong cases was followed with a time-interval of 40 seconds between the stimuli and with distraction obtained by reading during the interval. Intermingled with the triad series were two series of single notes given under like conditions. For these single stimuli the limiting notes of the triad, *i. e.*, *B-c*, and *f-sharp-g*, were chosen.

Quantitative Results. The experiment was so tedious that

¹ Thus, assume the triad *c-e-g* to be the standard. The Appunn tonometer might give this chord by the use of stops 528, 660, and 792 vibs. The smallest pitch-interval possible is four vibrations. If we take for the variable stimulus the next stops above the standards, we obtain the series 532, 664, and 796 vibs., whereas, in order to form a perfect triad upon the basis of 532 vibs., the two higher stops should give 665 and 798 vibs. respectively. The Appunn tonometer, without special tuning is, therefore, not available for the purposes of this experiment, for the mistunement of intervals which it necessitates is a disturbing factor sufficient to vitiate the tests. Tuning forks are difficult to adjust both delicately and quickly and to strike simultaneously. The newly improved Stern tone-variator is the only instrument satisfying the peculiar conditions of a test in the *sensible discrimination* of the pitch of chords.

but a small number of cases were tried, but the result was so unequivocal and was so firmly substantiated by the introspective reports as to leave no room for doubt upon the score of incompleteness. With the lower pair of single notes there were 75% right cases, with the upper pair of single notes 85%, with the triad only 45%. In other words, *under the conditions of the experiment a half tone is a sub-liminal difference for a triad, but a supra-liminal difference for single clangs in the same region.*

Qualitative Results. The introspective reports show that the distraction (reading difficult technical papers in which the observer was interested) was, as a rule, broken by one or two momentary resurgences of the image in a faint, cloudy form. Less often the distraction was complete. In no case was the image present in consciousness distinctly through any appreciable part of the forty seconds time-interval. Two seconds before the second stimulus a warning 'now' was given. At this time it was not uncommon for the image of the first stimulus to reassert itself in consciousness, either of its own insistence or as the result of active 'searching' on the part of the observer. On the other hand, in many, possibly in the majority of the tests, there could be seen that very interesting phenomenon of a correct judgment passed with assurance in the utter lack of anything approaching an image of the standard stimulus. Many times when *B* was aroused from his reading by the 'now,' running commentaries on the judgment process like the following were noted. "Is that the second note? . . . It is! I have no idea where the first was. . . . Well, then, this must be 'higher.' It feels that way, and I am quite sure about it."

Wherever the mechanism of the decision was revealed it was evident that the isolated clangs were judged more obviously upon a pitch basis,—not wholly auditory, but rather upon the basis of a quasi-spatial one-dimensional continuum with vague visual references to their positions upon the piano key-board. The triads, on the other hand, did not differ from each other so clearly in pitch or in their spatial position in the continuum. Generally the difference between the two triads was easily noted, but the direction of the difference was uncertain. When the direction of the difference was judged it was commonly upon

the basis of "a kind of exciting brightness" if 'higher,' and upon the basis of "a kind of subdued gentleness" if 'lower,' rather than upon any semi-spatial 'upness' or 'downness.' A similar distinction between the clang and the chord is remarked in the imaging of the first stimulus,—as, for instance, just after the second warning signal; in such cases the chord was imaged as a whole with little spatial reference, though by putting attention upon a note in the chord, the 'place-pitch' of this note could be ideated.

In the light of this introspective evidence and of the striking numerical result, we conclude, therefore, that *the pitch of a chord is more difficult to remember and to discriminate than the pitch of a single note.* A chord is, to be sure, more specific, more individual, than a clang, but its individuality as a chord, as a specific musical complex, is gained at the loss of individuality of pitch. As a given combination of intervals a chord is specific; as an auditory quality it is less individual than a clang. The essential feature of a clang is its position in the tonal continuum. A triad has no such definite position; or rather it is three positions given simultaneously and in fusion. Thus the discrimination of its pitch is more difficult because the quality of the stimulus is less 'clean cut.'

B. THE MELODY.

The study of the memory and pitch discrimination of a melody as compared with a clang was carried on under conditions practically identical with those just described. It will be seen that the simple melodic form employed embraced all the clangs in the region occupied by the triad used above, while the highest and lowest notes (those used as single stimuli for comparison) were struck twice each and formed the accentuated notes of the melody. The melody figured, when repeated, a half tone lower, formed the other stimulus.



Results. Our experiments were too few in number to admit of definite quantitative formulation. They showed clearly,

however, that, under the conditions employed, *the memory and discrimination of the pitch of melodic form is as good as, possibly better than, the memory and discrimination of the pitch of single clangs in the same tonal region.*¹

The introspection showed that, as in the case of the triad, the image was apt to be reconstructed as a whole at the warning signal, *i. e.*, the entire melody was heard. But again, as before, there were numerous judgments based entirely upon the second stimulus.

It is evident that the use of a number of successive clangs in place of a single clang does not have any confusing effect like the use of a number of simultaneous clangs. On the contrary, the effect is probably to multiply the opportunities for identifying the pitch of the standard stimulus. Now, if we assume that this greater ease of discrimination in the case of the melody, which the numerical results indicate, is a fact, we may further ask whether the use of a melodic form *as such* facilitates the discrimination. In other words, would not the same effect have been secured by striking a single note seven times instead of striking five different notes once or twice each? I am inclined to answer in the affirmative. The essential feature of a melody lies not in its pitch, but in the musical relationships of its constituent members. We should, therefore, *a priori*, suppose that the introduction of a melodic form into a series of successive clangs would not *per se* facilitate either the memory or the discrimination of the absolute pitch of the clangs involved.

Unfortunately the limitations of the time available for this test have neither permitted us definitely to establish the supremacy of the melody over the clang nor to investigate the question just raised as to the comparative influence of the melodic form itself and that of simple repetition of a single clang.

Summary. As tested on the piano with half-tone intervals in the small octave, with a time-interval of 40 seconds and

¹ The actual percentage of right cases for the melody was 95, as compared with 75 and 85 for the lower and upper limiting clangs respectively.

with distraction, the pitch of a chord is more difficult to remember and to discriminate, than the pitch of a single clang.

As tested under the same conditions, the pitch of a simple melody is as easily remembered and discriminated as the pitch of a single clang, possibly more easily. In the latter case it is not clear whether the increased facility is due to the melodic form itself or merely to the greater number of stimuli employed.